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EFFECTS OF COOPERATIVE CONCEPT MAPPING TEACHING APPROACH ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN BIOLOGY IN GUCHA DISTRICT, KENYA

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Abstract

This study investigated the effects of using Cooperative Concept Mapping (CCM) teaching approach on secondary school students' achievement in Biology. A non-equivalent control group design under the quasi-experimental research was used in which a random sample of 4 co-educational secondary schools was obtained in Gucha District. These 4 schools were randomly assigned to four groups. Each school provided one Form Two class for the study hence a total of 156 students were involved. Students in all the groups were taught the same Biology content but in two groups they were taught through CCM approach while the rest were taught through regular teaching methods. Before the four-weeks course started, the students were trained in cooperative learning techniques. Two groups were pre-tested prior to the implementation of CCM treatment. At the end of teaching, all the four groups were post-tested using the Biology Achievement Test (BAT). Data were analysed using the t-test, ANOVA and ANCOVA. The results show that students exposed to CCM approach have significantly higher achievement than those taught through regular methods. The researchers conclude that CCM is an effective teaching approach which biology teachers should be encouraged to use.

Introduction

Biological knowledge plays a significant role in enhancing Kenya's social economic development by enabling exploitation of land, animal and other natural and human resources (UNESCO, 1986). In addition, it is vital in maintenance of good health and hygiene.

However, inspite of this importance of biology, the Kenya Certificate of Secondary Education (KCSE) examination results show that most students have

been performing poorly (Kenya National Examinations Council [KNEC], 2002). The Kenya National Examinations Council (2002) identifies the approach used in teaching Biology as a key factor which contributes to this poor students' performance. In particular, the use of expository teaching approaches has been blamed for the poor performance.

Cooperative Concept Mapping (CCM) is a teaching approach which draws from concept mapping and cooperative teaching strategies. In CCM approach, students are put into groups of four or five making sure that the elements of cooperative learning are observed (D'Amico & Schmid, 1997). Students in each group promote one another's success by helping, explaining, elaborating, encouraging and supporting one another's efforts to achieve. Achievement of each individual is assessed and the results given to the group and the individual. Also, students organise biological concepts in a hierarchical manner from the more inclusive concepts to the more specific less inclusive ones (Kinchin, 2000).

This study attempted to find out from an experimental mode how students' achievement is affected by the use of CCM teaching approach. It also attempted to find out how the students' gender affects their achievement.

Conceptual Framework

The conceptual framework used in this study was based on the constructivist theory of learning. In this theory, the teacher serves as a facilitator who attempts to structure an environment in which the learner organises meaning at a personal level (Cooper & Robinson, 2002).

The study was based on the assumption that a teaching method that involves students' cooperation and activity is more likely to lead to worthwhile learning than a transmission teaching method (Hanrahan, 1998). The study therefore involved students in construction and reconstruction of concept maps. Diagrammatically, the framework is represented as follows: -

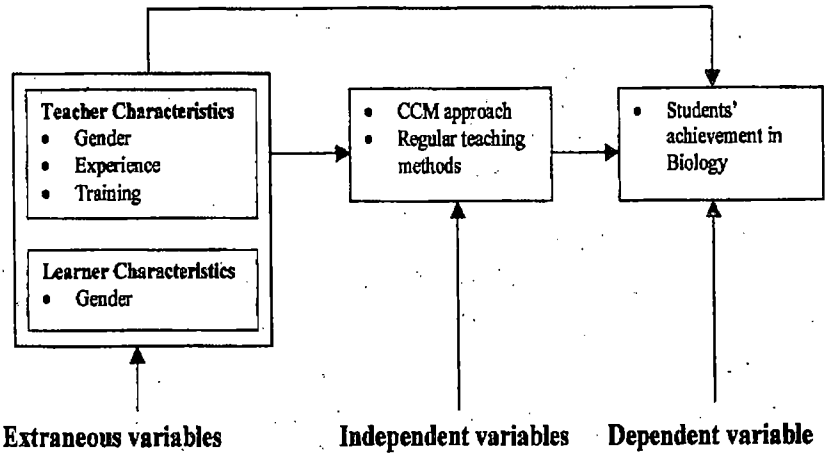

Figure 1: Conceptual Framework for Determining the Effect of using Cooperative Concept Mapping Teaching Approach on Students' Achievement in Biology.

The study involved trained biology teachers who had two or more years of teaching experience. Involving Form Two students who were approximately the same age controlled the variable of students' age.

Purpose and Objectives of the Study

This study was designed to determine the effect of using CCM approach on students' achievement in Biology. Its specific objectives were:-

- to determine whether there is a statistically significant difference in students' achievement in biology between those taught using CCM and those taught using regular methods.

- to determine whether there is a statistically significant gender difference in biology achievement when students are exposed to Cooperative Concept Mapping (CCM).

Hypotheses of the Study

The following null hypotheses were tested.

H_{01} There is no statistically significant difference in biology achievement between students exposed to CCM teaching approach and those that are exposed to regular methods.

H_{02} There is no statistically significant gender difference in biology achievement when students are exposed to CCM teaching approach.

Research Design

The study involved quasi-experimental research in which the researchers used non-equivalent control group design. The reason for this was that secondary school classes, once constituted, exist as intact groups and school authorities do not normally allow such classes to be broken up and re-constituted for research purposes (Borg & Gall, 1996). The research design is represented as follows:-

Group I	O_1	X	O_2
Group II	O_3	-	O_4
Group III	-	X	O_5
Group IV	-	-	O_6

Where: O_1 and O_3 are pre-tests; O_2, O_4, O_5 and O_6 are post-tests. X is the treatment where students were taught using Cooperative Concept Mapping approach (CCM). Group I is the experimental group which received the pre-test, the treatment X and the post-test.

Group II is the control group, which received a pre-test followed by the control condition and lastly a post-test.

Group III received the treatment X and a post-test but did not receive the pre-test

Group IV received the post-test only.

Groups II and IV were taught using regular methods.

This is the Solomon Four-Group Design used because it is considered suitable in achieving the following purposes:-

- Assess the effect of the experimental treatment relative to the control treatment.
- Assess the effect of a pretest relative to no pretest.
- Assess interaction between pretest and treatment conditions.
- Determine the extent to which the groups are uniform before giving the treatment (Borg & Gall, 1996).

Sampling Procedures and Sample Size

The sampling unit was the secondary schools and not individual students since students operate as intact groups. The study used district secondary schools to ensure that students involved had academic abilities that were comparable. A list of district secondary schools in Gucha District was used as a sampling frame. Convenience sampling technique was used to select four schools that formed the study sample. Sampled schools were a good distance apart to minimize experimental treatment diffusion. In schools that had more than one Form Two stream, simple random sampling was used to pick one stream for the study. The schools in each group were as follows: -

Group 1 (Experimental group), N = 43, Nyamondo Secondary School

Group II (Control group), N = 45, Makomoni Secondary School.

Group III (Experimental group), N=38, Moteiribe Secondary School

Group IV (Control group, N=30, Magenche Secondary School

A total of 156 Form Two students were assigned to the four groups.

Instrumentation

Biology Achievement Test (BAT)

The Biology Achievement Test was developed and used as a pretest. The numbering of the test items was re-organized for it to be used as a post-test. The test had 28 items, which carried different scores ranging from 1-6. The items tested knowledge, comprehension and application of what had been learned. The test was based on Form Two topic of Excretion. The test was given to experts in Science Education for moderation. It was also given to two secondary school biology teachers for validation. The test was then pilot-tested using two secondary schools in Kisii District which had similar characteristics as the sample schools. This was used to estimate its reliability. Since the items were not scored dichotomously and scores took a range of values, the reliability coefficient of the test was estimated using Cronbach's coefficient alpha (a) (Thorndike & Thorndike, 1994).

$$\alpha = \frac{K}{K-1}\left[1-\sum\frac{S_i^2}{S_x^2}\right]$$

Where K = number of items on the test

S^2_x = Variance of test x

S^2_i = Variance of item I

Its reliability coefficient was found to be 0.834. According to Fraenkel and Warren (1990), an alpha value of above 0.7 is considered suitable to make possible group inferences that are accurate enough. Therefore the BAT instrument was found to be reliable enough. The instrument was then used to collect data.

The Construction and Use of Instructional Materials

The researcher developed an instructional manual for the teachers to use during the treatment period. The manual was based on the revised KIE biology syllabus

(2003). The teachers of the experimental groups were trained by the researcher on the skills of cooperation in learning and concept mapping for one week. The teachers of the experimental groups then taught the students using CCM approach on a different topic other than Excretion for three weeks to enable them to master the skills. After this period the pretest was administered to Group I and Group II. Treatment period was four weeks.

The teacher first discussed with students various concepts in a given sub-topic or content and then afterwards let the students break into groups to draw concept maps on the content learned. The teacher then discussed various concept maps presented by different groups in class with the students before moving to a new lesson topic. The control groups were taught through regular methods. At the end of the treatment period a post-test was administered to all the groups. In sampled schools that had more than one Form Two stream, all the Form Two students in that school were taught using a similar teaching approach.

Data Collection

For this study BAT was used to collect data. The researcher administered the instrument with assistance of biology teachers in respective schools. Groups I and II were given pre-tests before the start of the treatment. This was followed by the treatment, which took four weeks. After the treatment, the researcher, with the assistance of concerned teachers administered post-tests to the four groups. The researcher then scored the tests. This generated quantitative data.

Data Analysis

Data were analysed using one-way Analysist of Variance (ANOVA) and analysis of covariance (ANCOVA). Analysis of Variance (ANOVA) was used to determine if the four groups differed significantly among themselves on variables being studied. Analysis of Covariance (ANCOVA) was used to cater for initial differences among the groups. In detecting differences between two means, a t-test was used because of its superior quality in detecting differences (Borg & Gall, 1996).

Results

The Solomon Four – Group Design used in this study enabled the researcher to have two groups sit for pre-tests. Groups I and II sat for the pre-test BAT. This enabled the researcher to:-

i) Assess the effects of the pre-test relative to no pre-test.

ii) Assess if there was an interaction between the pre-test and the treatment condition.

iii) Assess the similarity of the groups before administration of the treatment (Borg & Gall, 1996).

Table 1: Independent Samples t-Test of the Pre-test Scores on BAT

Group 1, N = 43; Group 2, N = 45

Variable	Group	Mean	Std Dev.	t-value	p-value
BAT	1	4.49	2.69	1.78	0.078 (ns)
	2	3.28	3.53		

Std Dev. = standard deviation

BAT – Maximum score = 80

ns – not significant at $p<0.05$ level

An examination of Table 1 shows that the mean scores for groups 1 and 2 on BAT were not statistically different $t(86) = 1.78$, $p>0.05$. This shows that the groups were quite similar before commencement of the study.

Effects of CCM on Students' Achievement in Biology

To determine the relative effects of CCM teaching approach on students' achievement in biology, an analysis of students' post – test scores in BAT was carried out. This was to test hypothesis Ho_1.

Table 2 shows BAT post-test mean scores obtained by the students. The results of the one-way ANOVA based on these means are shown in Table 3

Table 2: BAT Post-test Mean Scores Obtained by the Student in the Four Groups

Group	N	Mean score
1	43	36.38
2	45	20.39
3	38	36.18
4	30	14.63

Table 2 shows that Groups 1 and 3 which were experimental groups had higher mean scores than Groups 2 and 4 which were control groups.

Table 3: Analysis of Variance (ANOVA) of the Post-test Scores on the BAT

	Sum of squares	df	Mean square	F	p-value
Between groups	12826.37	3	4275.46	42.98	.00 (s)
Within groups	14026.99	152	99.48		
Total	26853.36	155			

s = significant at $p<0.05$

Table 3 shows that there was a significant difference between the means $F(3,152) = 42.98$, $p<0.05$. It was then necessary to carry out further tests on the combination of means to find out where the difference occurred (Post-Hoc tests). Bonferroni Post-Hoc procedure was used. Table 4 shows the results of Bonferroni Post-Hoc comparisons.

Table 4: Post-Hoc Comparisons of the Post-test BAT Mean Scores for the Four Groups

	(I) Group	(J) Group	Mean difference (I-J)	p-value
Bonferroni	1	2	15.990*	0.00
		3	0.200	1.00
		4	21.751*	0.00
	2	1	-15.990*	0.00
		3	-15.790*	0.00
		4	5.761	0.116
	3	1	-0.200	1.00
		2	15.790*	0.00
		4	21.550*	0.00
	4	1	-21.751*	0.00
		2	-5.761	0.116
		3	-21.551*	0.00

* = the mean difference is significant at $p<0.05$

The results in Table 4 show that the pairs of BAT mean scores of Groups 1 and 2, Groups 1 and 4, Groups 2 and 3 and Groups 3 and 4 were significantly different at the 0.05 level. However, the mean scores of Groups 1 and 3 and 2 and 4 were not significantly different.

Table 5 shows the adjusted BAT means score for ANCOVA with KCPE scores as covariates. Table 6 shows analysis of covariance of the post-test BAT scores

with KCPE scores as covariates. It shows that there is a statistically significant difference in the BAT mean scores of the four groups.

Table 5: Adjusted BAT Post-test Mean Scores for ANCOVA with KCPE Scores as Covariate

Group	N	Means Score
1	43	36.92
2	45	23.63
3	38	33.03
4	30	16.59

Table 6: Analysis of Covariance (ANCOVA) of the Post-test Scores on BAT with KCPE Scores as Covariates.

	Sum of squares	df	Means F square	F	p-value
KCPE	11123.09	1	11123.09	934	0.00
Group	7527.84	3	2509.28	210.77	
Error	1535.76	151	11.91		

Table 7 shows ANCOVA pairwise comparisons on BAT post-test scores. It shows that the pairs of BAT mean scores of Groups 1 and 2, Groups 1 and 4, Groups 2 and 3 and Groups 3 and 4 were significantly different at the 0.05 level. However, the mean scores of Groups 1 and 3 and Groups 2 and 4 were not significantly different. This supports the results obtained through analysis of variance.

Table 7: ANCOVA Pairwise Comparisons on BAT Post-test Scores for the Four Groups.

(I) Group	(J) Group	Mean difference (I-J)	p-value
Bonferro·	2	13.29*	0.00
	3	3.89	0.100
	4	20.33*	0.00
	1	-13.29*	0.00
	3	-9.40*	0.00
	4	7.04	0.118
	1	-3.89	0.100
	2	9.40*	0.00
	4	16.44*	0.00
4	1	-20.33*	0.00
	2	-7.04	0.118
	3	-16.44*	0.00

* = The mean difference is significant at $p<0.05$

The results indicate that:

i). The BAT pre-test did not interact significantly with the treatment conditions. If it was not so, the groups that took the pre-test would have obtained significantly different results from those that did not.

ii). The pre-test did not interfere with the learning of the content by students.

iii). The use of CCM teaching approach resulted in higher students' achievement than the conventional teaching methods since Groups 1 and 3 obtained scores that were significantly higher than the other groups. Hypothesis Ho_i is therefore rejected.

Achievements of Boys and Girls Who were exposed to CCM Teaching Approach.

To find the gender difference in achievement when students were exposed to CCM teaching approach, the researchers computed the BAT mean scores for boys and girls and then compared them to determine whether there was significant difference between them. Table 8 shows the pre-test BAT mean scores for boys and girls who were exposed to CCM teaching approach.

Table 8: Pre-test BAT Mean Scores for Boys and Girls Exposed to CCM Teaching Approach

Gender	N	Mean	Std. Deviation	Standard Error
Boys	45	4.63	2.86	0.583
Girls	36	4.32	2.54	0.583

Table 9 shows the t-test of pre-test BAT mean scores for boys and girls exposed to CCM.

Table 9: shows the t-test of pre-test BAT mean scores for boys and girls exposed to CCM.

Gender	N	Mean	Std. Deviation	t	df	p-value
Boys	45	4.63	2.86	0.37	79	0.71
Girls	36	4.32	2.54			

From Table 9 the difference between the BAT mean scores for boys and girls is not significant $t(79) = 0.37$, $p>0.05$. It indicates that boys and girls were at the same level of achievement in Biology at the start of the treatment.

Table 10 Shows post-test BAT mean scores for boys and girls exposed to CCM.

Table 10: Post-test BAT Mean Scores for Boys and Girls Exposed to CCM Teaching Approach.

Gender	N	Mean	Std. Deviation	Standard Error
Boys	45	35.93	9.88	1.51
Girls	36	36.74	9.29	1.59

Table 11: Independent Samples t-Test of the Post-test BAT Scores of Boys and Girls Exposed to CCM

Gender	N	Mean	Std. Deviation	t	df	p-value
Boys	45	35.93	9.88	-0.37	75	0.72
Girls	36	36.74	9.29			

Table 11 shows the t-test results on the post-test scores. Table 12 shows the ANCOVA of the post-test BAT scores using KCPE scores as covariates.

Table 12: ANCOVA of the Post-test BAT Scores of Boys and Girls Exposed to CCM (with KCPE Scores as Covariates)

	Sum of squares	df	Mean square	F	p-value
Gender	48.375	1	48.375	0.703	0.403
KCPE	16794.42	1	12794.42	0.00	0.00
Error	9015.23	78	68.82		

Table 12 indicates that there is no statistically significant gender difference in achievement when students are exposed to CCM teaching approach $F(1, 78) = 0.703$, $p>0.05$. This confirms the findings from ANOVA.

From Tables 11 and 12, it can be concluded that the mean scores for boys and girls exposed to CCM teaching approach are not significantly different. Hypothesis Ho_2 is therefore upheld.

Discussion

The Effects of CCM on Students' Achievement in Biology

The researchers found that students who were taught through the CCM approach achieved significantly higher scores in the BAT than those taught through the regular approaches. This implied that the CCM teaching approach was more effective in enhancing student's achievement than the regular approaches.

An earlier study conducted by Wachanga (2002) comparing the effects of traditional and co-operative class experiment learning strategies on students achievement and motivation in secondary school chemistry also found significant difference in achievement. In his study group rewards were based on the individual learning of the group members. The present study has yielded similar results.

Sherman (1989) studied the effects of using group investigation co-operative learning model on the achievement of secondary school biology students and found no significant difference in post-test achievement scores between the co-operative and competitive groups. However, his findings may have been a result of implementation weaknesses. The only way a team can succeed is to ensure that all team members' activities focus on explaining concepts to one another, helping one another during practice and encouraging one another to achieve (Slaving, 1992). Sherman seems not to have taken this into account in his study. Johnson and Johnson (1992) argue that simply being a member of a co-operative group in and of itself does not promote higher achievement. There has to be clear positive interdependence structured among members' outcomes for the increased effort required for higher achievement to be exerted.

According to FAWE (1998), one of the key factors influencing the quality of education is the quality of the teacher and the teaching carried out in the classroom. This depends on the curriculum of the teacher training at pre-service or in-service level. If the teacher training is flawed, the quality of teachers and teaching will also be flawed. In the present study teachers were carefully trained on the skills of co-operative learning and concept mapping. They then used the new approach in order to master the skills. This assisted greatly in improving students' achievement.

Students worked in mixed ability teams and ensured that all team members learned so that the team member's activities focused on explaining concepts to one another, helping one another practise and encouraging one another to achieve. (Slaving, 1992). This approach should be encouraged in secondary schools because of its positive effects on achievement.

The Effect of CCM on the Achievement of Boys and Girls

The results in this study have shown that there is no statistically significant difference between the achievement of boys and girls who are exposed to CCM

teaching approach. In Kenya, girls perform poorly in sciences when compared to boys at KCSE. The CCM teaching approach assists girls to improve their achievement level.

In a research study aimed at improving the participation and performance of girls in science and mathematics in primary and secondary schools, it was reported that girls achievement in sciences in Kenya was much lower than that of boys partly due to their poor attitude towards sciences. It also indicated that teachers in normal competitive classes use discouraging remarks on girls participation in learning (FAWE, 1998). This in turn affects their self-esteem and confidence resulting in poor performance.

Some teachers knowingly or unknowingly make remarks in class that discourage girls participation in learning. Some assume that girls could not answer specific types of questions that are of higher taxonomy (Wachanga, 2002). UNESCO (2004) also argues that teachers often consider girls as less intelligent and destined to lower paid jobs than boys. Girls are also given little praise compared to boys.

In this study boys and girls of mixed abilities were in equal proportions in each group. The teacher was able to give similar attention and equal treatment to both boys and girls and the communication barrier between them was broken. Boys received explanations from girls while girls also received the explanations from boys. This made the performance of girls to be equally good as that of boys in the study. Therefore, the disparity in performance between boys and girls at KCSE biology was addressed by using CCM teaching approach.

Implications of the Study

The CCM teaching approach results in higher students achievement. The approach should therefore be used in biology teaching at secondary school level. Girls have been performing dismally in science at national examinations compared to boys. But when students are exposed to CCM teaching approach, gender does not affect their achievement in Biology. This implies that this method could make girls perform equally as boys in Biology.

Education inspectorate in its efforts to make Biology teachers more effective should encourage them to use this method. Teacher training institutions should incorporate the CCM concepts in their training curriculum in order to produce teachers who can use the new approach.

Conclusions

The following conclusions have been reached from this study:-

- The CCM teaching approach facilitates students learning in biology than the regular teaching methods.
- Gender does not affect students' achievement in Biology when they are taught using CCM teaching approach.

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